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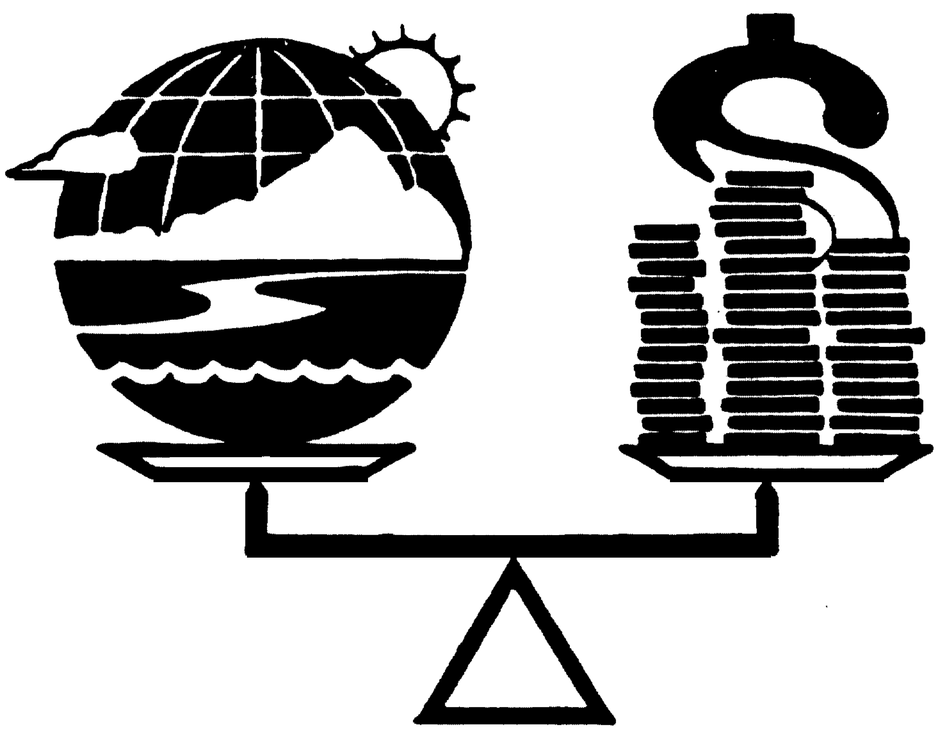

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VALUING RISKS:
NEW INFORMATION ON THE
WILLINGNESS TO PAY FOR CHANGES IN FATAL RISKS

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[MORTA]

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1.0 INTRODUCTION

This report updates the Violette and Chestnut (1983) report which assembled and reviewed estimates of the willingness to pay for changes in fatal risks. The 1983 report compiled the available empirical estimates in one reference source, presented a critical discussion of the estimates, and discussed their usefulness in environmental policy assessment. Since its publication, several studies have produced new estimates. Some of these studies directly address weaknesses pointed out in the earlier review, so the estimates now can be re-evaluated.

The 1983 review focused on willingness-to-pay (WTP) and willingness-to-accept compensation (WTA) estimates for valuing changes in risks. Other valuation approaches have been used including estimates of future earnings that would be lost due to an increase in deaths or illness, and estimates of medical expenses associated with an increase-in illness and death. Although providing useful benchmarks, these approaches do not provide estimates of the benefits to the individual of reducing or preventing health risks because they do not reflect the change in utility, or well-being, that would result from the change in risk of illness or death. WTP measures reflect how much of other goods and services the individual is willing to give up in order to obtain a reduction or prevent an increase in health risks. Correspondingly, WTA measures reflect how much a person would have to be paid to accept an increase in risk. These measures, therefore, give a dollar estimate of the change in well-being that the individual has or expects to experience. Summing this measure, of individual benefits across all affected individuals can provide the benefits component of a benefit-cost analysis.

In this report, results of the different studies are compared by reference to the estimated "value of life." This is not meant to be thought of as an amount of money that an individual would accept in exchange for his or her life. Instead, it is a way of comparing valuations for small changes in small risks that affect a large number of people. For example, say a certain environmental decision will reduce the risk of death from exposure to a given toxic substance from 3 out of 10,000 to 1 out of 10,000 for a total population of 10,000 people. Implementing the policy would, on average, save two lives. These are termed statistical lives since the change is in the statistical risks faced by the population, and there is no way in advance to identify which two individuals in the population would be saved. If each of the 10,000 individuals is willing to pay $100 for this reduction in the probability of his or her death, then the total willingness to pay is

($100 per person X 10,000 people) = $1,000,000

and, given that two lives are saved, the value per statistical life is $500,000.

The 1983 report examined studies that fell into three general categories:

1. Wage-risk studies that use data from the labor market to examine workers' trade-offs between on-the-job risks and wages.
2. Consumer market studies that examine individuals' purchases. of products that influence safety, such as smoke detectors.
3. Contingent market studies where hypothetical markets are constructed and survey respondents are questioned about their willingness to pay for changes in levels of safety.

The previous review did not include the primarily theoretical literature concerning the relationship between the "value of life" and "human capital," as expressed largely by a person's lifetime earnings. This work has focused on the conceptual basis for determining when a person's human capital can be viewed as a lower bound to the value of life. Mishan (1982) pointed out that any hypothesized relationship between a statistical value of life based on WTP and a human capital figure is essentially an empirical question which cannot be answered until we have empirical estimates of the "value of life" based on willingness to pay. This review has therefore focused on empirical willingness to pay estimates.'

While a substantial literature on the valuation of fatal risks has been published since the previous report, this update focuses on studies that we judge to be most important for shedding new light on the valuation of risks.

The studies emphasized in this update have analyzed new data sets rather than re-examining data sets used in previous studies. This is not meant to minimize the contributions from using different model variations for existing data sets, which certainly provide valuable information on the robustness of the results. However, one of the principal criticisms of the earlier work on the value-of-life estimates was that most of the wage-risk studies used one of only two sets of data on job risks and, as a result, did not produce independent estimates. Further, the willingness-to-pay estimates were found to lie in roughly two groups corresponding to the selection of the risk variable data set. This makes wage-risk studies that use new and different data on job risks particularly useful.[2]

In addition to the new wage-risk valuation studies, several recent risk valuation studies have used contingent market approaches. These new contingent market studies represent a considerable advancement over the ones reviewed in the earlier report. Estimates from the earlier contingent market studies were viewed as largely unreliable due to various methodological problems. Two new studies specifically address the criticisms presented in the earlier review and produce estimates deserving careful consideration.

Six new studies will be emphasized in this report. Each one uses new data on risks. Four use data from labor markets and base estimates on wage-risk premiums. The remaining two studies use contingent market survey methods. Some additional studies are mentioned as their results have some bearing on the overall conclusions. The studies examined in detail are:

1. Wage-Risk Studies: Marin and Psacharopoulos (1982); Dillingham (1985); Duncan and Holmlund (1983); and Gegax, Gerking, and Schulze (1985).[3]

2. Contingent Market Studies: Jones-Lee, Hammerton, and Philips (1985) and Gegax, Gerking, and Schulze (1985). Jones-Lee _et al._ use a contingent market approach to examine the willingness to pay for reduced risks in travel, while Gegax _et al._ examine contingent bids for a safer workplace.

2.0 VALUE-OF-LIFE ESTIMATES FROM LABOR MARKET ANALYSES OF WAGE-RISK TRADEOFFS

This section discusses four hedonic wage-risk studies that address specific criticisms and concerns about the wage-risk literature reviewed earlier in Violette and Chestnut (1983). One criticism of the previous wage-risk studies was that they relied on only two available data sets on job risks. The estimates from these studies clustered into two groups depending on which measure of risk was selected. Table 1 presents the results of these studies. The studies that found value-of-life estimates in the lower range used actuarial risk estimates compiled from insurance data, while those that found estimates in the higher range used industry-specific job risks compiled by the U.S. Bureau of Labor Statistics.4

One difference between the two risk measures is that the actuarial risk measure may incorporate factors other than occupational risks. First used by Thaler and Rosen (1975), these data were obtained from a 1967 survey conducted by the Society of Actuaries. The survey provides data on the death rates associated with selected occupations. To obtain a measure of occupational risks from these data on total fatalities, Thaler and Rosen subtracted the age-adjusted expected deaths for the population from the death rate for each occupation. The remainder was assumed to represent deaths associated with the occupation. Constructed in this manner, the risk variable measures the extra risk to the insurance company of insuring those who are in a particular occupation.

These actuarial risk data result in an unexpected ranking of the risks associated with each occupation. For example, elevator operators, bartenders and waiters were calculated to have higher risks of death than policemen or firemen. This may be because the risk estimates reflect both true occupational risks and risks associated with worker characteristics. Rather than bartending being a particularly risky occupation, it may be that people attracted to this profession have personal habits or characteristics which increase their insurable risk independent of their occupation. On the other hand, people who work as firemen or policemen may be in better physical condition thereby reducing the incidence of illnesses or accidents leading to death. To the extent that an occupation's higher death rate is caused by

Table 1

Labor Market Based Estimates of the Marginal Willingness to Pay for Reductions in Risks

Study	Mean Risk Level for the Sample[a]	Value Per Statistical Life (millions of 1984 dollars) All Estimates[b]	Judgemental Best Estimates
LOW RANGE ESTIMATES (all based on actuarial risk data)			
1. Thaler and Rosen (1975)			
a. Without risk interaction terms	11.0	.42 .54 .58 .80	
			.61
b. With risk interaction terms	11.0	.01 .21 .30 .36	
2. Arnould and Nichols (1983)	11.0	.69	.69
HIGH RANGE ESTIMATES (all based on BLS industry accident rates)			
3. R. Smith (1976)	1.0 and 1.5	3.47 3.70	3.55
4. V.K. Smith (1982)	3.0[c]	1.86[d] to 5.57	3.80
5. W.K. Viscusi (1978[b])	1.2	1.57 2.40 2.86 3.70 4.25 4.53 4.71	4.20
6. C. Olson	1.0	7.64	7.64
7. R. Smith (1974)	1.0 to 1.5	8.09 14.20	8.09

a Approximate annual deaths per 10,000 workers.

b For different model specifications. Estimates from all specifications are shown since one outlier can distort the range.

c Assuming .4 percent of all injuries are fatal, as reported by Viscusi (1978b) for the BLS injury statistics.

d Assuming the risk premium for fatal injuries ranged from 33 percent to 100 percent of the premium for all risks.

personal characteristics that are attached to the individual rather than associated with the job, there will be no positive compensating wage differential. In fact, if these characteristics are attached to the person, they could have the opposite effect, i.e., result in lower wages for these occupations.. Having individuals as employees who are more likely to incur injuries may increase the cost of doing business. This would result in lower productivity and, therefore, lower wages being offered to these individuals.

Even if the actuarial occupational risk data were entirely accurate, it is questionable that it would match the perceptions of individuals in the labor market who are negotiating their wage-risk premiums. The ranking of occupations by risk implied by the actuarial data does not conform to usual expectations. One of the assumptions of the hedonic technique is that the participants have accurate information regarding the risk characteristics of the job.

In contrast to the actuarial data, the data compiled by the U.S. Bureau of Labor Statistics have the advantage of reporting only work related fatalities by industry group. This measure still has problems since job risks are not likely to be uniform across occupations within the same industry. For example, clerical workers and heavy equipment operators classified as being in the same industry will have very different risks of injury. Also, the BLS on-the-job injury data do not include all long-term illnesses that may be associated with exposures to harmful substances in the workplace and may result in premature death. As a result, there is measurement error in both the actuarial and the BLS industry measures of risk used in earlier studies. In general, the BLS industry risk measure is viewed as being the more appropriate. Still, additional research using new risk data sets is needed. The four studies reviewed below each use a different risk data set.

2.1 STUDY 1: Marin and Psacharopculos (1982)

Marin and Psacharopoulos (M&P) use data from the labor markets in the United kingdom to determine whether compensating wage differentials exist for jobs that have higher risks of death. In addition to this primary objective, M&P examine the influence of different job risk measures on the estimated value of life.

Data and Estimation Methods

M&P obtained data on job risks classified by 223 occupational groups from surveys conducted by the Office of Population Censuses and Surveys. The risk measures were based on detailed records of deaths by occupation registered over the three-year period 1970 through 1972. This is the first study to use this data base on job risks and, given the paucity of risk data, its results are an important contribution to the literature on the value of life as estimated by wage premiums.

M&P constructed a number of risk variables. The two measures that were given the greatest attention were termed ACCRISK and GENRISK. The ACCRISK variable solved a number of the problems associated with both the actuarial risk measure and the BLS risk measure used in U.S. studies. Their ACCRISK measure was based on deaths caused by an accident <u>at work</u>. It was constructed by subtracting the expected on-the-job accidental death rate, given the age structure of the occupation, from the actual rate of on-the-job accident fatalities. The influence of personal characteristics that are not job related is reduced by using a risk measure based only on accidents at work. Raving occupation-specific risk measures also reduces the errors-in-variables problem present with the BLS industry risk measures. For these reasons, the ACCRISK variable constructed by M&P is superior to any of the risk variables used in the studies of the U.S. labor market referenced in Table 1.

The second risk measure, GENRISK, was defined as the extra risk of dying in each occupational group and was calculated as the actual death rate minus the death rate that could have been expected given the age and social class structure of workers in the occupational group. Since GKNRISK was calculated in the same way as Thaler and Rosen's actuarial risk variable, it is subject to the same criticisms as their risk measure.

The empirical model estimated by M&P was a conventional earnings function:

$$\ln Y = f(S,\ EX,\ BX\ \text{squared},\ \ln \text{WEEKS},\ \text{RISK},\ \text{UNION},\ \text{OCC},\ \text{UNIONxRISK}) + \text{error};$$

where Y is annual earnings, S is the number of years of schooling, EX is years of experience in the labor force, WEEKS is the number of weeks worked in the survey year, RISK is one of the risk measures, UNION is the proportion of the workers covered by a collective bargaining agreement, and OCC is a measure of occupational desirability based on the Goldthorpe and Hope (1974) scale.

Results

The M&P results show that earnings in the United Kingdom do, in fact, compensate for higher work related risk. The difference between estimates using the ACCRISK and GENRISK risk measures is interesting. The estimated coefficients on the GENRISK measure were an order of magnitude smaller than those based on the more appropriate ACCRISK measure. Using the ACCRISK measure,the estimated value of life ranged from 603,000 British pounds to 681,000 British pounds. Using an approximate exchange rate of 2:1 for this time period, these estimates roughly translate into a range of $1,206,000 to $1,362,000 in 1975 dollars.

In an interesting-side analysis,M&P construct industry risk measures comparable to the BLS measure used in many of the U.S. studies. These industry-based risk measures produced higher estimates of the value of life than were found when the occupation specific ACCRISK measure was used. The implied value of life was about 2 million British pounds.

M&P also estimated wage-risk premiums for certain worker subgroups. Three subgroups were examined: (1) managers and professionals, (2) nonmanual workers,and (3) manual workers. M&P found the job risk coefficient to be insignificant in the equation for managers and professional workers. This was felt to be due to the small variation in the risks across the occupations in this category. The risk variable coefficient was positive and significant for the other two worker classifications. The implicit value-of-life estimates based on these estimated risk coefficients ranged from 2,259,000 to 2,245,000 British pounds for nonmanual workers and from 619,000 to 686,000 British pounds for manual workers. The difference in the estimate for these two worker classifications is large. More weight should probably be given to the manual work estimates since the standard errors of the estimates for nonmanual workers were much larger relative to the estimated coefficients.

M&P drew several conclusions from their analyses. In particular, when viewing the labor force as a whole, the implicit values of life were found to fall into the 600,000 to 700,000 (British pounds) range. Translating this into 1975 U.S. dollars gives a range of $1,200,000 to $1,400,000. When the sample was split, the range of values of life for manual workers was similar but the range for nonmanual workers was approximately three times greater.

Also of interest were the M&P results using the different measures of risk. When the more conceptually correct measure of risk was employed the resulting estimates were approximately an order of magnitude greater than when the actuarial type of risk measure was used. Further, this result held up for industry risk measures similar to those based on the BLS data in the U.S. studies, which produced even higher estimates than the occupation-specific measure of on-the-job accidents. This led M&P to conclude that:

> "The reason previous U.S. studies have differed in the value of life that they estimate is mainly that the high-valued studies used the more relevant concept of risk, namely accidents at work."

When converted into 1984 dollars,the results of wage-risk analysis based on occupation-specific measures of on-the-job accidents by M&P support a value of life that falls in the upper range of estimates presented in Table 1.

There is one criticism that can be leveled at the earnings function that was estimated by M&P. In their equation,they use a variable OCC to measure of occupational desirability. This measure is an index of how people rate the desirability of different occupations. It is not clear that OCC is truly an independent variable. In particular, M&P present evidence that job safety and the amount of required education may be positively related with the OCC desirability index. This being the case, a more appropriate estimation probably would have been two stage least squares.

2.2 STUDY 2: Dillingham (1985)

The recent Dillingham study is similar to the work by M&P in several respects. Dillingham uses a measure of job risks other than the actuarial risk measure or the BLS industry measure. This permits an evaluation of the wage-risk relationship with an independent data set. As in the M&P study, Dillingham delineates risks both by occupation and industry which reduces measurement error in the risk variable and allows for an examination of the influence of different risk measures on the estimated value of life. Finally, Dillingham's work sheds new light on what was felt to be a key issue in assessing the empirical estimates of the value of life for policy applications in the previous Violette and Chestnut (1983) review. In that review, it was believed to be likely that the low range of estimates resulted from the use of an incorrect, or at least deficient, measure of job risks. All of the studies that produced estimates in the low range used the actuarial type of risk measure with one important exception-- the Dillingham (1979) study. This study used a different and seemingly more appropriate risk measure and still came up with a value of life in the low range. This result was pivotal to the conclusion in the earlier review that the low range estimates, based on the information then available, could not be ignored when presenting the range of value of life estimates for policy purposes. However,Dillingham (1985) shows that the risk measure used in his earlier study was flawed and, when corrected, his empirical results also fall into the upper range. This leaves only studies using the questionable actuarial risk measure in the low value of life range.

Data And Estimation Methods

The data on job related fatalities used by Dillingham were compiled from records at the New York State Workman's Compensation Board.' The data from the Workman's Compensation Board were detailed enough to allow for the construction of both occupation and industry risk measures. In all, Dillingham constructed five risk measures and examined their implications for the value-of-life estimates. Four of these were based on the Workman's

Compensation Board data which allowed very detailed industry and occupation breakdowns., The most disaggregated risk measure consisted of about 13,000 industry/occupation categories, similar to the risk measure used in Dillingham (1979). The second had about 200 industry/occupation categories. The third was risk by industry group (similar to the BLS measure) and the fourth was risk by occupation group. The fifth risk measure was based on data from the BLS on industry-wide risks to explore the empirical significance of alternative risk measures.

Dillingham estimated several hedonic wage-risk equations using these risk measures with data on individual workers from two different sources: (1) the 1977 Quality of Employment Survey conducted by the Survey Research Center at the University of Michigan, and (2) the 1970 Census in New York State (the same data used in Dillingham, 1979).

Results

With the Quality of Employment Survey, Dillingham found a statistically significant risk coefficient for all but the most disaggregated risk measures. The implied value of life estimates ranged from $1.4 million to $3.8 million (1979 dollars), with a mean of $2.4 million. The highest value was obtained with the BLS risk measure. The author placed less confidence in this result because it was not stable when industry/occupation dummy variables were added suggesting that the risk coefficient may reflect some effect other than risk. Dillingham favored the estimates in the $1 million to $2 million range.

The results obtained with the 1970 Census data for New York suggest a problem with the more disaggregated risk measures. The risk coefficient for the most disaggregated risk measure was statistically significant, but the implied value-of-life estimate was only $340,000 to $380,000 (1979 dollars). This is in the same range as the Dillingham (1979) results ($140,000 to $450,000) using a similarly disaggregate risk measure. The value increased with less disaggregated risk measures. With the major industry/occupation groupings (about 200 categories),the value-of-life estimate was about $870,000, and with the occupation groups alone it was $1.1 million to $1.3 million. Dillingham argues that the more disaggregated risk measures are not appropriate due to the fairly infrequently occurrence of fatal injuries. He suggests that the similarity between the results for the two different worker samples in this analysis, in terms of the value-of-life estimates associated with each risk measure, supports the conclusion that the 1979 study results may have been the result of errors-in-variables bias. It is also of interest that in contrast to the findings of M&P, the occupation risk measure yielded higher values than the industry risk measure based on the Workman's Compensation data for both worker samples.

In addition to producing these new value-of-life estimates, Dillingham draws a number of conclusions regarding the bimodal distribution of past estimates shown in Table 1. He states that his analysis significantly alters the interpretation of the labor market value-of-life estimates. The low value estimates "are all from studies using the actuarial data from Thaler and Rosen . . . the so-called high estimates are based on a variety of risk measures all of which have one element in common: they reflect the extra risk assumed at work." If these low estimates are "either ignored or adjusted upward, the bimodal character of the estimates is eliminated and the mean value of the labor market estimates is in excess of $1 million (1979 dollars)."

Dillingham's work supports and extends the conclusions of M&P. It provides furthur evidence that the appropriate range of estimates for the value of life should exclude the low estimates found by Thaler and Rosen. More significantly, this study provides an independent set of value-of-life estimates, most of which are greater than $1 million in 1979 dollars.

2.3 STUDY 3: Gegax, Gerking, and Schulze (1985)

The work by Gegax, Gerking, and Schulze (GGS) addresses several of the criticisms that have been directed towards the hedonic wage-risk studies. One frequently mentioned concern is that workers may not be well informed with respect to the actual risks of different occupations so that their perceptions of job risks may be different from the accident rates used in the wage-risk studies. The result is that occupational rankings based on the workers' perceptions of risk may not be the same as rankings based on the actual rate of fatal accidents. GGS address this concern by obtaining information on workers' perceptions of the relative riskiness of their own occupations and then using these perceived risks in a wage-risk study. Another concern often expressed about hedonic wage-risk studies stems from the restricted sample of workers used in each study. GGS avoid this second problem by using data for the workers in a national random sample of U.S. residents.

Data and Estimation Methods

The data used in the GGS study were collected by means of a national mail survey which was conducted during the summer of 1984. Information was collected on annual labor earnings, the perceived risk of fatal accidents at work, the individual's human capital, work environment, and personal characteristics. To obtain information on perceived risks, an illustration, of a ladder with equally spaced steps labeled from one to ten was provided. Seven example occupations were placed on the ladder according to their average levels of job-related risks of death. The examples ranged from jobs such as school teachers to risky occupations such as lumberjack. The respondent was then asked to specify the step number which came closest to describing the risk of accidental death on his or her primary job. GGS argue that this variable may be a more accurate measure of the individual's self-assessed risk of death at work than other industry or occupation measures.

GGS used this self-assessed risk measure in a conventional hedonic wage equation for the entire sample and for several subsamples of workers.

Results

The result for the entire sample is shown in the first line of Table 2. The coefficient on the risk variable was not significant at conventional levels, but was of the expected sign. Disregarding the low t-statistic, the estimated coefficient yields an estimated value of life of $.727 million (1983 dollars). Investigating possible reasons for the lack of statistical significance, GGS investigate differences in the wage-risk relationship across different occupational groups. Two concerns are addressed. One concern with the use of the full national sample is that there may be insufficient variation in the risk variable to drive the hedonic waqe variable. A second concern is that in jobs where there are extremely low risks of accidents, the marginal value of reducing risks further may be zero and no wage-risk gradient may exist. To

Table 2

Hedonic Wage-Risk Results

From Gegax *et al.* (1985)

Subsample	Coefficient	t-Statistic	Mean Risk Level[1]	Value-of-Life ($ millions)
Full Sample	.0073	.995	2.6	.727
Union-Blue Collar Workers	.0159	1.879	4.0	1.495
Union-White Collar Workers	.0541	1.611	1.8	5.981
All Union Workers	.0176	1.852	3.3	1.753

NOTE: The dependent variable for all estimations was the natural logarithm of the 1983 average wage adjusted for regional price differences. All non-union specifications yielded insignificant results.

[1] deaths per 4,060 workers annually

[2] in 1983 dollars

explore these issues, GGS segmented the sample into unionized blue-collar workers, unionized white-collar workers, nonunion blue-collar workers, and nonunion white-collar workers.

The results of the hedonic estimation for selected subsamples are shown in Table 2. The statistical significance of the risk variable increased in subsamples with higher mean risk levels, but the risk variable was not significant in the nonunion equations. The mean risk variable was approximately 50 percent higher for the all-union sample (includes both blue-collar and white-collar workers) than for the nonunion sample, however, nonunion blue-collar workers still had risk levels considerably higher than the mean of the full sample. This could indicate a possible market failure where only union members are able to obtain higher wages for higher risks.[5] GGS suggest that this may be as much due to unions providing information on safety risks as it is to the increased bargaining power of the union.

white-collar workers had both the lowest mean risk levels and the lowest standard deviations. The lower significance of the risk variable may be because there is insufficient variation in risks across white-collar occupations or because the marginal value of lowering risks still further is zero. GGS state that these workers may have positive values of life when measured at the margin, but the hedonic method may not be able to estimate these values; alternative techniques such as contingent valuation methods may be superior for obtaining these estimates. Given these concerns, GGS selected $1.5 million (1983 dollars) as their judgemental best estimate of the statistical value of life based on the hedonic wage-risk estimations.

For comparison purposes, the authors also estimated the hedonic wage function using the BLS fatal injury rate by industry in place of the perceived risk measure. In #is case, statistically significant coefficients were obtained for the union and all blue-collar samples, similar to the results with the perceived risk variables, but the implied values per life were considerably higher at about $6 to $10 million. These values overlap with'the highest results obtained for one of the union samples with the perceived risk measure. Combined with the results of M&P and Dillingham, this suggests that value-of-life estimates using the BLS industry injury rates may be overstated, but it should be noted that the same magnitude of difference did not occur between Dillingham's industry and occupation estimates obtained using the Workman's compensation data.

viscusi and O'Connor (1984) used an approach similar to GSS to estimate wage premiums for on-the-job risks of injury (including fatal and non-fatal). They conducted a survey of workers in the chemical industry and asked them to estimate their risks of injury relative to other private sector workers in the U.S. Using this self-perceived risk measure, they found a statistically significant annual risk premium of $740 to $790 (1982 dollars) per worker for the blue collar sample. The risk coefficients were not consistently statistically significant for the full sample (similar to the findings of GSS). It is not possible to calculate a value per fatal injury from the information reported by the authors, but the estimated wage premium is quite comparable to that estimated by viscusi (1978b) using the BLS injury data. Results of the 1978 analysis indicated an annual risk premium of about $1000 per worker and a value per fatal injury of about $2.5 to $4 million (1982 dollars).

2.4 STUDY 4: Duncan and Holmlund (1983)

This hedonic wage study uses a unique data set on job characteristics which provides another independent reference point for estimates of compensating wage rate differentials. The particular job risk variables used by Duncan and Holmlund (D&H) are only indirect measures of job risks and, as a result, can not be converted into value-of-life estimates. Still, the analyses and findings from D&H are supportive of the general hedonic wage method. This is valuable in itself, given that a new, independent data set is used in the study. Also, D&H use a different estimation technique which is made possible by their longitudinal data set.

Data and Estimation Methods

The data used by D&H are from two surveys of workers in Sweden -- one conducted in 1968 and the second in 1974. The surveys covered a wide array of personal and job characteristics. The job characteristics were classified into four broad categories: (1) hours constraints (inflexible hours), (2) hard physical work (heavy lifting, physically demanding, daily sweating), (3) stressful work (mentally demanding, hectic), and (4) dangerous work (noise, smoke, shake, exposure to chemicals). All of the job characteristics were 0-1 dummy variables.

Results

D&H employed an estimation procedure that was made possible by their longitudinal panel data. The same individuals were interviewed in both 1968 and 1974. The variables were entered in the wage equation in change form, i.e., the net change in these variables between 1968 and 1974. The hypothesis being tested is that the change in the wage rate over this time period is a function of the changes in personal characteristics and job characteristics. D&H use this wage change formulation to control for the effects of unmeasured and unchanging characteristics of workers. If important characteristics such as motivation and intelligence lead to both higher pay and better working conditions; then, the omission of these worker characteristics will bias the estimated relationship between wages and working conditions, but will not necessarily bias the relationship between the change in wages and the change in working conditions.

D&H estimated wage equations using cross-sectional data for each of the years, as well as estimating the wage change equation. The cross-sectional specifications produced many coefficients on the job characteristic variables that had "wrong" signs. The wage change equation resulted in many more reasonable coefficients on the job characteristic variables. The index of dangerous working conditions was associated with a compensating wage differential using the change equation, but not with the cross-sectional specification. The same was true for the index of stressful working conditions.

The index of dangerous working conditions could not be translated into a risk of death measure which could then be used to calculate a value-of-life estimate. As a result, this study does not provide us with another value-of-life estimate. Instead, the importance of these results is additional evidence they provide that workers do respond to job related characteristics such as risks, using a data set that is independent of those used in previous studies.

3.0 VALUE-OF-LIFE ESTIMATE!3 FROM CONTINGENT VALUATION STUDIES

In the earlier critique of empirical estimates for valuing reductions in risks,violette and Chestnut (1983) reviewed the five contingent valuation studies that were then available. The 1983 review concluded that most of these studies had not used state-of-the-art techniques, all suffered from potentially severe shortcomings, and their estimates were not reliable. However, two recent contingent valuation studies (Jones-Lee et al., 1985; and Gegax et al.,1985) use state-of-the-art methods and represent important contributions to the value-of-life literature.

Contingent valuation studies and revealed preference approaches (such as the hedonic wage method discussed in the previous section) are the two procedures used to obtain estimates of the willingness to pay for reductions in risks. Revealed preference approaches attempt to identify instances where individuals actually trade off risks for income or other goods. The labor market studies are the most common revealed preference studies. The CV approach uses a questionnaire format to construct a hypothetical market where the individual can express his preference for alternative levels of income and safety. Each procedure has strengths and weaknesses. The revealed preference approach has the advantage of being based on actual decisions. While this is a strength, the researcher is limited to using data on actual market situations that may differ from what is needed for a specific policy analysis in either the type of risk faced or the particular individuals making the tradeoff. The Cv approach has the advantage that it can be tailored to address the specific question of interest. It can be applied to a general population sample or to a subsample of the population, and it can address changes in risks of the specific magnitudes of interest. The principal disadvantage is that the CV approach is based on what people say rather than what they do.

3.1 STUDY 1: Jones-Lee, Hammerton, and Philips (1985)

This study is a considerable improvement over the five contingent market studies reviewed in Violette and Chestnut (1983). The criticisms of these earlier studies encompassed, among other things, that the samples were nonrandom or too narrow to provide estimates applicable to public policy questions; the scenarios and payment mechanisms were not well defined; the change in risks being valued was not clearly presented; and there was little checking for "problem" bids or consistency across bids. All of these issues were addressed by Jones-Lee, Hammerton, and Philips (JHP).

Data and Research Methods

The JHP study examined individuals' WTP and WTA for changes in the risks of motor vehicle accidents resulting in injuries or fatalies. The work was funded by the United Kingdom Department of Transport. A final questionnaire was developed through a process that included extensive pilot testing of the questions and detailed modification of the survey instrument. The questionnaire contained questions that fell into three broad classifications: (1) valuation questions designed to obtain estimates of the values individuals placed on changes in risks; (2) perception and consistency questions designed to test the individuals' ability to handle the probability concepts and stability of responses; (3) factual questions concerning vehicle ownership, income, age and other experience/personal data.

Serious doubts about the credibility of valuation responses were expressed by some members of the U.K. Department of Transport at the beginning of the research effort. Two particular concerns were stated. The first was that there would be no way of knowing whether responses to hypothetical valuation questions were, in fact, related to the individual's true willingness to pay. Second, there was concern about whether the respondents could understand the probability concepts presented in the questionnaire and provide reliable estimates in response to the questionaire scenarios. To the extent possible, JHP tried to build a system of checks into the questionnaire. Tests for consistency and perception bias were incorporated to detect cases of misrepresentation, random guessing in valuation responses, or an inability to handle the probability concepts. To mitigate risk perception bias, the risks of each travel mode were presented to the respondent numerically and pictorially. To test for stability of the responses, a followup questionaira was administered to selected participants approximately one month after the first survey was completed.

JHP obtained 1,103 full responses that,when used with appropriate weights, were representative of the general population of Great Britain. Acton (1972) conducted the only other CV study to use a general population sample but this study was limited by the size of the sample -- only 32 complete responses. The type of risk examined by JHP was one most people regularly face -- risks of death in a motor vehicle accident. The scenarios and payment mechanisms were realistic and well defined. This makes the results potentially more applicable to the general population than those of the best previous CV study (Acton, 1972), which used fatalities following heart attacks, risks that may not be very high for the average individual (or at least will vary a lot between high risk and low risk segments of the population). The public-good (free-rider) problem in the survey questionnaire was mitigated by defining risks and payments associated with transportation in a private good context -- payments that would specifically reduce risks to yourself. Payment mechanisms were: (1) an increase in bus fare in return for greater safety, and (2) a higher price for a new, safer car. The general types of questions are depicted below:

1. Commercial bus fatalities - You have been given $400 for travel expenses in a foriegn country and given the name of a coach service which will take you on your itinerary for exactly the amount on money you have been given. The risk of being killed on the journey with this coach firm is 8 in 100,000. You can choose to travel with a safer coach service if you want to, but the fee will be higher, and you will have to pay the extra cost yourself.

   a) How much extra, if anything,would you be prepared to pay to use a coach service with a risk of being killed of 4 in 100,000?

   b) How much extra, if anything,would you be prepared to pay to use a coach service with a risk of being killed of 1 in 100,000?

2. Similar questions were asked concerning the willingness-to-pay for additional safety features in a new car that would reduce the risks of death to the driver (if you do not drive assume that you do).

Results

The survey was conducted during the summer of 1982 and, using an average dollar-to-British-pound exchange rate of 1.76, the empirical results from JHP are presented in Table 3. The average value-of-life estimates ranged from roughly $2 million to $4 million (1982 dollars). One interesting finding was

Table 3

Summary of Results of WTP

From Jones-Lee *et al.* (1985)

Type of Risk	Initial Level of Risk	Increment of Risk	(1982 U.S. Dollars) Mean Response Per Life	Median Response Per Life
1) Commercial bus fatality	$8x10^{-5}$	$-4x10^{-5}$	$2.8x10^{6}$	$2.2x10^{6}$
	$8x10^{-5}$	$-7x10^{-5}$	$2.4x10^{6}$	$1.3x10^{6}$
2) Automobile fatality-drivers	$10x10^{-5}$	$-5x10^{-5}$	$2.1x10^{6}$	$.88x10^{6}$
	$10x10^{-5}$	$-2x10^{-5}$	$3.9x10^{6}$	$1.4x10^{6}$

the skewness of the distribution of responses. In all instances, the median bid was lower than the mean value-of-life and ranged from $.88 to $2.2 million. The difference between the mean and median value-of-life estimates raises questions concerning which is the most policy relevent. Since the median represents that value of life that has 50 percent of the estimates below that number and 50 percent above that number, a democratic voting process would indicate the the median should be employed. The skewness of the distribution implies that more than 50 percent of the individuals have values of life less than the mean value. The use of the mean could have the result that a minority of individuals with high values of life may be "dragging along an unwilling majority" (Jones-Lee et al., p.70).

JHP conducted a number of analyses attempting to explain the variation in risk valuation estimates across individuals. A number of potential explanatory variables were used in a statistical regression framework. These variables included income, age, social class, miles driven, car ownership, accident experience, and other personal data. In general, the explanatory power of these statistical models was low. Only the age and income were generally significant and they were not significant in all of the equations. The income elasticity from those equations where the coefficient on the income variable was significant was approximately .3. This indicates that changes in the distribution of income would result in only minor changes in the statistical value of life.

The results of some, but not all, of the consistency checks employed by JHP were encouraging. Among the encouraging findings were that 75 percent of the responses were coherent, i.e., conformed with standard axioms of rational choice for simple decisions under uncertainty. With respect to the consistency of responses in multipart valuation questions, only 8 percent of the responses were higher for smaller reductions in risks (plainly inconsistent). The stability of responses was examined by re-questioning a subsample of respondents one month later. No statistically significant differences in the means was found, but the standard deviation was larger in the second round of responses. The effect of the order of the questions was also investigated and found not to be a significant influence on the estimates. Finally, the respondents were asked whether they found the questions easy or difficult to understand. The majority found the questions understandable.

While some of the consistency checks were encouraging, some potential problems were found. Forty-two to forty-seven percent of the respondents gave the same WTP estimate for different reductions in risk. While not plainly inconsistent, the frequency of the same dollar response for different reductions in risk may indicate that people place a value on reducing risk, but may not be able to distinguish between one level of risk and another within the magnitudes of risks used in this questionnaire. On another question designed to assess the respondents understanding of the uncertainty concepts, respondents were asked:

> "Imagine that you have to face two different risks of being killed:
> - in one, your risk of death is 2 in 100,000
> - in the other, your risk of death is 20 in 100,000.
>
> You cannot avoid either of these risks but you can choose to have one reduced. Which would you prefer:
> - the risk of 2 in 100,000 reduced to 1 in 100,000
> - the risk of 20 in 100,000 reduced to 15 in 100,000"

Approximately 47 percent of the respondents expressed a preference for a reduction in the risk of 2 in 100,000, i.e.,a reduction of 1 in 100,000 being preferred to a reduction of 5 in 100,000. While this is an apparently inconsistent answer, eliminating these respondents did not change the mean value-of-life estimate.

JHP evaluate the various consistency checks and conclude that the balance of the arguments are strongly in favor of regarding the value-of-life estimates as a reliable indication of the order of magnitude of the "true" value. They also compare their estimates to those obtained by Marin and Psacharopoulos (1982) using occupational data and find the consistency of the estimates encouraging and state that this consistency confirms the expected hypothesis that individuals tend to be roughly equally averse to the prospect of dying in a transport accident and in a accident at work.

The responses to a few other questions are also of interest to the evaluation of environmental hazards. In one line of questioning, respondents were told that current annual deaths due to three causes were:

4,000	motor vehicle accidents
11,000	heart disease
16,000	cancer

When asked if one cause could be reduced by 100, which would they select, 76 percent said cancer. The authors interpret this as indicating that death due to cancer is worse than death due to motor vehicle accidents or heart disease. This may be the case, but the interpretation may be confounded by the higher amount of cancer deaths; people may simply find it more desirable to reduce the largest cause of death.

In response to another question, respondents indicated that they are willing to pay additional amounts to reduce risks to others as well as to themselves. These additional amounts are approximately one-third of their WTP to reduce their own risks.

Another contingent valuation study also found evidence that subjects may have difficulty evaluating changes in very small probabilities of death. Smith et al. (1985) conducted a contingent valuation study concerning risks of exposure to hazardous wastes and subsequent risks of premature death 30-years after exposure. The responses varied considerably depending on the risk increment and the question (either WTP to obtain a reduction in risk or WTP to prevent an increase). Due to the two-part risk of death and the 30-year time component, the responses are not directly comparable to those obtained by JHP, but Smith _et al._ did calculate some roughly comparable annualized "value-of-life" estimates based on their findings. For average annual changes in probabilities of death roughly comparable to those hypothesized by JHP the estimates are between $1.5 and $7 million (1984 dollars). Although respondents generally gave rational answers for increments to their posited initial risk level, those who had larger posited risk levels, closer to on-the-job risk levels, gave values corresponding to a value-of-life from $200,000 to $1,000,000. Those with very small initial risk levels gave bids that implied values two orders of magnitude larger.

3.2 STUDY i: Gegax, Gerking and Schulze (1985)

In addition to performing a hedonic wage-risk analysis with their survey data, Gegax, Gerking, and Schulze (GGS) incorporated contingent valuation questions in their survey. The random sample of U.S.wage earners used by GGS is an improvement over the samples used in earlier contingent valuation studies.

Data and Estimation Methods

In one-half of the sample, respondents were asked how much of an increase in annual wages would be required to get them to voluntarily work at the same job if the risk of job related death were one step higher on the risk ladder than where they initially placed their current job related risk of death (WTA). The other half of the survey sample was asked how much of a decrease in wages they would accept if their job related risk of death were moved one step down on the ladder (WTP). These questions were based on the same risk measures used by GGS in their hedonic wage-risk analysis which allows for some comparability between the two components of the study.

The survey procedures used in this study were substantially improved over the contingent valuation studies previously reviewed in Violette and Chestnut (1983). With respect to scenario development and realism, the concept of on-the-job risks was introduced reasonably well with preliminary questions about job safety, but the concept of trading off wages against risks is not introduced before the WTP/WTA questions were asked. The authors did not note any problems with lower response rates with these particular questions, which is about the only indication of problems that this mail format allows. Past studies have seen protest responses to questions of this type. These protests are in the form of "I couldn't get by with less money", or "I wouldn't take a job that would increase my risk of accident". GGS offer no indication of whether or not protest bids posed a problem.

Results

The results of the WTP and WTA questions are shown in Table 4. The WTP measure gives a mean value of about $2,600,000. The results for the different

Table 4

Contingent Valuation Results

From Gegax et a1. (1985)

	Mean Risk Level[1]	Mean Value Of Life Based On WTP[2]	Mean Value Of Life Based On WTA
ALL WORKERS	2.6	$2,558,000	$7,404,000
ALL UNION	3.3	$2,789,000	$7,384,000
UNION WHITE-COLLAR	1.8	$2,030,000	$7,156,000
UNION BLUE-COLLAR	4.0	$2,952,000	$7,480,000
NON-UNION WHITE-COLLAR	1.6	$2,531,000	$7,436,000
NON-UNION BLUE-COLLAR	3.7	$2,544,000	$7,342,000

[1] Number of deaths per 4,000 workers.
[2] 1983 Dollars

subsamples of workers show that the values are very consistent across the different worker samples,in contrast to the results of the hedonic wage-risk analysis. This supports the earlier argument of the authors that white-collar workers probably place a significant value on reducing or avoiding risks but that there is insufficient variation in risks to obtain a significant risk coefficient in a hedonic wage equation.

The WTA estimates are on the order of three times greater than the WTP estimates. Deferring to the substantial body of evidence that has been accumulated suggesting that the willingness to accept measures of value are biased upwards, GGS suggest $2,600,000 as a best value-of-life estimate from this contingent value study (1983 dollars). This can be compared to their best estimate of $1.5 million from the hedonic wage study.

4.0 OVERALL CONCLUSIONS

The different value-of-life estimates obtained from the new studies reviewed in this update are presented in Table 5 in 1984 dollars. In general, the methods employed in these studies are superior to the earlier work reviewed by Violette and Chestnut (1983). These new results indicate that a value-of-life estimate based on the types of risks faced by workers on the job are likely to exceed $1.6 million (1984 dollars). There is strong evidence that some of the low value-of-life estimates obtained from early wage-risk studies are the result of biases in the measured risk variable and should not be included in the range of empirical estimates.

In the earlier Violette and Chestnut review, potential biases in the value-of-life estimates from hedonic wage models were discussed. The bias of most concern was whether potentially important explanatory variables were omitted from the hedonic wage equations. The issue was whether high job risks may be correlated with other unpleasant working conditions with the result being that the risk variable is acting as a proxy for other unpleasant working conditions rather than capturing a true wage-risk premium. This is the potential bias most likely to result in overstated values for reductions in risks. The two contingent valuation studies provide additional information that indicates that wage premiums are due to job risks. In particular, Gegax <u>et al.</u> (1985) were able to hold all factors other than job risks constant in their contingent valuation study and still find a WTP similar to the estimate obtained from their hedonic model.

Two of the studies have estimated hedonic wage equations using risk data from sources other than the BLS and then re-estimated the equations using the BLS data. The results suggest that the BLS data may give higher value-of-life estimates and may be reflecting job characteristics other than risks alone. The highest values obtained for manual or blue-collar workers with non-BLS risk data were about $2.5 million. It is not clear whether the higher results obtained with the BLS data are due to the data being for industry-wide injury levels. M&P found very high values using a similar non-BLS industry variable while Dillingham did not.

Table 5

Estimates from Recent Studies

(millions of 1984 dollars)

	Mean Risk Level for the Sample[a]	Range of Values	Judgerental Best Estimate
WAGE-RISK STUDIES			
1. Marin and Psacharopoulos (1985)			
a. manual workers	b	2.3 – 2.6	2.4
b. non-manual workers	b	6.4 – 6.5	6.4
2. Dillingham (1985)	1.4 – 8.3	1.2 - 5.4	2.1
3. Gegax et al. (1985)			
a. total sample	6.5	.80	
b. union workers only	8.2	1.6 - 6.2	1.6
CONTINGENT VALUATION STUDIES			
4. Jones-Lee et al. (1985)[c]	0.8 - 1.0	2.2 – 4.2	3.0
5. Gegax et al. (1985)[d]			
a. WTP	4.2 – 10	2.1 – 3.1	2.7
b. WTA	4.2 - 10	7.5 – 7.8	

[a] Approximate annual deaths per 10,000 individuals.

[b] Marin and Psacharopoulos used an age adjusted normalized risk variable which is not directly comparable to the risk levels used in other studies. However, the average risk of death for the entire sample was 2 in 10,000.

[c] The estimates came from valuing decrements in risk. The large number of individuals not responding to questions about their WTA for increased risks made estimates based on risk increments unreliable.

[d] The highest WTP estimate is from a subsample of union blue-collar workers, the lowest is from a subsample of non-union blue-collar workers. The estimate for all workers was $2.67 million (1984$).

Most of the authors placed greater confidence in the hedonic wage results for manual and blue-collar workers. Higher value of life estimates were sometimes obtained with the full or white-collar samples, but statistical significance was weaker. It appears that there may be insufficient variation in risks across many of these jobs to allow for estimation of a risk premium. The contingent valuation results support the conclusion that the different results for blue-collar and white-collar workers are due to different job risk characteristics rather than due to different risk preferences on the part of the individuals. This is contrary to what is sometimes argued, which is that one group may be more risk averse than the other and that this accounts for the differences in results. The low mean risk levels as well as the small variation in risks across white-collar jobs may make the application of the hedonic method unreliable and Gegax et al. suggest that contingent valuation techniques may be more appropriate for obtaining value-of-life estimates for this segment of the population.

In summary, this updated review suggests a possible narrowing of the range of values for on-the-job risks of death to $1.5 to $3 million. The lower-bound appears more solid than the upper-bound since these new studies fairly convincingly show that the actuarial risk data are not appropriate. However, values substantially above $3 million have been obtained with the BLS risk data or for non-manual worker samples. This review suggests that some upward bias or greater error may exist in these results, but this has not been firmly demonstrated. The values of up to $8 million should not be completely dismissed until further study is made of these potential problems.

This range of $1.5 to $8 million seems fairly well established for on-the-job risks and may be directly applicable for evaluating policies or regulations expected to affect risks of fatal injury in the workplace (although long-term risks due to exposures to hazardous substances may not be fully reflected). The results of the contingent valuation studies suggest that this range may also be appropriate for other population groups and for other types of voluntary risks of fatal accidents of at least a roughly similar magnitude, but more studies are needed to confirm this.

Further questions remain concerning whether these value-of-life estimates are appropriate for valuing reduced risks from environmental hazards. Arguments have been made that people place higher values on reducing risks that are involuntary, perceived as new and/or potentially catastrophic compared with those that are voluntary, familiar, and tend to affect small numbers when an "event" occurs (see Violette and Chestnut, 1983). Thus, values for reducing environmental risks may be higher than values for reducing job and transportation risks. We have little empirical information on this, so far, but that which is available seems to indicate that the values presented in Table 5 should be viewed as a lower bound to the value of life appropriate for environmental policy assessment.

Another interesting-policy issue raised by JHP (1985) concerns whether the mean or median value-of-life is most appropriate for policy analysis. Their study found a highly skewed distribution of value-of-life estimates where a few individuals had very high values of life. This result was also found by Loehman (1979) for values individuals placed on changes in morbidity risks. As far as we know, there has been no research on this question.

ENDNOTES

1. Landefeld and Seskin (1982) develop estimates using the human capital approach and adjust them to develop an approximation to WTP based on individuals' preferences. Their starting assumption is that a person's human capital is a lower bound to their WTP. While this seems likely, it has not been firmly established. Still, the Landefeld and Seskin adjustments seem plausible, although they do not fully consider potential pain. and suffering.

2. Authors of two empirical studies, not specifically reviewed in this update, have drawn the conclusion that the estimated value of life from wage-risk studies should not be used in the evaluation of public policies. Smith and Gilbert (1984) estimate an inter-city wage model including both air pollution levels and on-the-job risks and found very different value-of-life estimates implied by the coefficients for these two variables, with a much higher value based on the air pollution coefficient. They therefore argue that the wage-risk based estimates are unlikely to be correct for environmental applications. That may be true, but we are unwilling to place much confidence in their estimate based on the air pollution coefficient due to the extremely tenuous assumptions required in its calculation. Dickens (1984) based his negative conclusion about the usefulness of the wage-risk results on his finding of a negative and statistically significant coefficient on the risk variable in a non--union sample. His conclusion that this invalidates all wage-risk results is unwarranted without considerably more analysis of the structure of his data. Other studies reviewed here suggest that the variation in risk across a subsample and the role of the unions may be important, and that risk premiums may not be estimable for all subsamples.

3. Two other wage-risk studies were reviewed, but are not specifically presented in this paper.' They are Low and McPheters (1983) and Graham, Shakow, and Cyr (1983). The Low and McPheters study was limited to police officers, a subsample with unusual risk characteristics. They found significant wage differentials for police officers who work in more dangerous cities. The Graham, Shakos,and Cyr study used the same

actuarial risk measure employed by Thaler and Rosen (1976). Like other studies that have employed this risk measure, they derive an estimate for the value of life that is less than $.5 million. Ippolito and Ippolito (1984) conducted another study of potential interest that was not included in this review because the type of risk involved is very different than in most other studies. This is a consumer market study looking at cigarette smoking.

4. The 1983 report also included estimates in the lower range obtained by Dillingham (1979) using a third risk data set compiled from workers' compensation data for the state of New York. Based on subsequent analysis with these data, Dillingham concluded that his 1979 results were incorrect. We have therefore left these numbers out of Table 1. The new analysis of this data set reported by Dillingham (1985) is reviewed.

5. Other U.S. studies, including viscusi (1979), have found evidence of higher risk premiums for union members than for nonunion workers.

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